

UNITED STATES AIR FORCE RESEARCH LABORATORY

REPLICATION AND EXTENSION OF MODELS OF JOB PERFORMANCE RATINGS

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PREFACE

An earlier version was presented at the 1998 annual meeting of the Society for Industrial and Organizational Psychology, Dallas, TX.

The views and opinions expressed in this paper are those of the authors and do not reflect the official policies or opinions of their respective organizations.

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SUMMARY

This study tested causal models of job knowledge, job proficiency and supervisor ratings ($n = 838$ enlisted airmen). Results indicated that (a) effects of ability and experience were linear, not interactive, (b) different conceptualizations of "experience" play somewhat different causal roles, (c) general support for the mediational roles of job knowledge and job proficiency, and (d) supervisor ratings reflect both "can-do" and "will-do" aspects of performance.

REPLICATION AND EXTENSION OF MODELS OF JOB PERFORMANCE RATINGS

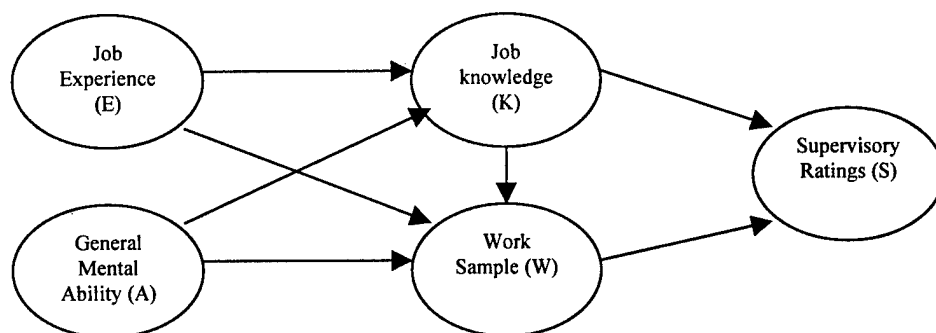
INTRODUCTION

The measurement and prediction of individual performance in organizations is a topic that is as much at the forefront of I/O psychology as it was near the turn of the 20th century (Austin & Villanova, 1992). Although a large number of theories have been developed concerning particular aspects of work behavior (e.g., work motivation, leadership, employee attitudes, etc., Campbell, 1990), few general theories of work performance have been developed (Campbell, Dunnette, Lawler, & Weick, 1970; Waldman & Spangler, 1989). Recently, however, a number of studies have begun to test general models of job performance and supervisory performance ratings.

Hunter (1983) developed and tested a causal model relating general cognitive ability, job knowledge, job proficiency, and supervisory job performance ratings. Hunter (1983) found that (a) the effect of cognitive ability on job proficiency was largely indirect, through the mediating influence of job knowledge, (b) job knowledge and job proficiency mediated effects of cognitive ability on supervisory performance ratings, and (c) both job knowledge and job proficiency exerted direct effects on supervisory performance ratings.

Schmidt, Hunter, and Outerbridge (1986) extended this model to include experience determinants of job knowledge, job proficiency, and supervisory ratings. This model (shown in Figure 1) recognizes that job knowledge is facilitated not only by general cognitive ability, but also by the accrual of additional job experience. Like cognitive ability, the effect of job experience on job proficiency was hypothesized to be substantially mediated by job knowledge. Schmidt et al. (1986) found that (a) both job experience and cognitive ability had large direct effects on job knowledge, (b) job experience and cognitive ability had direct but substantially weaker effects on job proficiency, (c) job knowledge had a large direct effect on job proficiency, and (d) job knowledge and job proficiency completely mediated the effects of job experience and cognitive ability on supervisory performance ratings.

FIGURE 1: Schmidt, Hunter, and Outerbridge (1986) model of job performance ratings



Three other studies have extended Schmidt et al.'s (1986) model in various ways. For example, Pulakos, Schmitt, and Chan (1996) found that many of the basic relationships hypothesized by this model were generalizable across ratee gender, ratee racial/ethnic groups, and rater level (supervisor vs. peer). In another study, Borman, White, Pulakos, and Oppler (1991) attempted to replicate Hunter's (1983) original findings. However unlike Hunter (1983), who found that job knowledge had a direct effect on supervisory ratings as well as an indirect effect (mediated by job proficiency), Borman et al. (1991) supported a complete mediation model – the effect of job knowledge on supervisory ratings was completely mediated by job proficiency. Borman et al. (1991) also augmented Hunter's (1983) original "can-do" model, with additional determinants of supervisory ratings that reflect "will-do" aspects of performance. As expected, supervisory ratings reflected the influences of both technical ("can-do") and motivational ("will-do") aspects of performance.

Several conclusions are suggested by these studies. First, they suggest that both cognitive ability and job experience are important determinants of job knowledge. Second, they suggest that the effects of cognitive ability and experience on job proficiency are largely indirect, being mediated by job knowledge. These findings help establish a theoretical linkage (i.e., the development of job knowledge) for these empirically established predictor-criterion relationships (e.g., Hunter & Hunter, 1984; Quiñones, Ford, & Teachout, 1995). Third, Borman et al. (1991, 1995) helped further establish the importance of distinguishing between "can-do" and "will-do" aspects of performance, or what have also been referred to as technical and interpersonal proficiency (Kavanagh, Borman, Hedge, & Gould, 1987) or contextual performance (Borman & Motowidlo, 1993; Motowidlo & VanScotter, 1994).

However, several questions remain unanswered. The first concerns the form of the effects of cognitive ability and experience on job knowledge (and perhaps technical proficiency). Schmidt et al. (1986) examined only linear and additive effects but there also is evidence for an interaction such that the relationship between cognitive ability and performance is stronger at lower levels of experience than at higher experience levels (Lance, Hedge, & Alley, 1989). This "convergence" relationship (Schmidt et al., 1988) suggests that higher ability incumbents would learn their job more quickly, but that with additional accrued experience, lower ability incumbents eventually "catch up." The first purpose of the present study was to test linear and additive versus interactive cognitive ability x experience effects on job knowledge.

The second question concerns the conceptualization of "experience." Schmidt et al. (1986, 1988) operationalized experience only in terms of "months-in-present-job." Quiñones et al. (1995) refer to this as a job-level time-related measure of experience. Time-in-job experience measures can be contrasted with, for example, task-level amount-related measures of the number of times tasks had been performed previously. Quiñones et al. (1995) showed that different types of experience measures bore different relationships with performance criteria: task-level and amount-related measures bore stronger relationships with criteria than alternative operationalizations of experience. The second purpose of the present study was to investigate alternative measures of experience (job-level time-related vs. task-level amount-related measures) as determinants of job knowledge and job proficiency.

The third question concerns the mediational nature of the models tested to date, and particularly the job knowledge → job proficiency → supervisory rating relationship. Hunter (1983), Schmidt et al. (1986), and Pulakos et al. (1996) found support for a partial mediational model, whereas Borman et al. (1991, 1995) supported a complete mediational model. The third purpose of the present study was to further test these mediational roles of job knowledge and job proficiency.

Finally, recent studies (Borman et al., 1991, 1995; Pulakos et al., 1996) have modeled factors relating to motivational, as well as technical, aspects of performance as determinants of supervisory performance ratings and found that supervisory ratings reflect both "can-do" and "will-do" aspects of performance. The final purpose of this study was to extend these findings comparing the effects of "can-do" versus "will-do" aspects of performance on supervisory ratings in an independent sample.

METHOD

Sample

Data reported here were collected as part of the Joint Service Job Performance Measurement (JPM)/Enlistment Standards Project conducted in the 1980s and early 1990s by the U.S. Air Force (USAF) (Hedge & Teachout, 1986; Kavanagh et al., 1987; Wigdor & Green, 1991). Data reported here were from four Air Force Specialties (AFSs) in which job knowledge measures (see below) were included as part of the JPM data collection process (Aircrew Life Support Specialist, $n = 229$; Precision Measurement Equipment Laboratory [PMEL] Specialist, $n = 140$; Aerospace Ground Equipment [AGE] Mechanic, $n = 269$; Personnel Specialist, $n = 200$).

Procedure

Briefly, each participant was assessed in a work sample test battery developed specifically for their AFS. Work sample performance was scored as a weighted (by relative criticality) percent of task steps completed correctly as recorded by the test administrator. Participants also indicated the number of times they had performed each task on the job prior to its being administered in the work sample test ("Number of Times Performed" or "NTP"). Finally, two additional measures reported here were collected prior to the examinee's arrival at the work sample test station: (a) self-ratings of "...the amount of relevant on-the-job experience..." on each task that they would be asked to perform in the work sample test battery ("Task Experience Ratings" or "TERs:" 1 = No or almost none, to 7 = A very great amount), and (b) supervisory performance ratings on the same tasks ("Supervisory Ratings:" 1 = Never meets acceptable level of proficiency to 5 = Always exceeds acceptable level of proficiency). Additional details of the USAF JPM project are given in Hedge and Teachout (1992), Lance, Teachout, and Donnelly (1992), and Laue, Hedge, Wall, Pederson, and Bentley (1992).

Measures

Cognitive ability. Research participants had completed the Armed Services Vocational Aptitude Battery (ASVAB) as part of their enlistment requirements. The Armed Forces Qualification Test (AFQT) is a composite of the four verbal and math ASVAB subtests and is accepted as a reliable (reliability of the AFQT is estimated at .90, Earles & Ree, 1992) and valid indicator of general cognitive ability (g, Murphy, 1984; Ree & Earles, 1992). We used AFQT scores as measures of cognitive ability.

Job experience. Consistent with previous studies (e.g., Schmidt et al., 1986, 1988), we used the total number of months in the present assignment as the measure of job experience. Since all research participants were first-term airmen, this measure corresponded to their Total Active Federal Military Service (TAFMS, in months). For purposes explained later, we assumed the reliability of TAFMS to be .95.

Task experience. We measured task experience as a composite of participants' reports of the number of times they had previously performed each work sample task (NTP) and their task experience ratings (TERs). Previous research (Lance et al., 1989; Lance et al., in press) has found that NTP ratings are markedly skewed and multimodal. We computed a transformed NTP (TNPT) as in previous studies to more approximately normalize NTP and equate its scale with TERs as 1 = 0 NTP, 2 = 1 to 10 NTP, 3 = 11 to 20 NTP, 4 = 21 to 50 NTP, 5 = 51 to 100 NTP, 6 = 101 to 800 NTP, and 7 = 801 to 999 NTP. For each task, task experience was computed as the mean of TNPT and TER. Overall, task experience (TaskExp) was measured as the mean task experience across all work sample tasks attempted (mean Cronbach's alpha across the four samples = .729).

Job knowledge. Written multiple choice job knowledge tests were developed specifically for tasks that were included in the work sample test batteries, and were administered to participants prior to the work sample test. The number of items in the job knowledge tests ranged between 93 (PMEL Specialist) to 159 (AGE Mechanic). Job knowledge test scores (JKTSs) were computed as the percentage of items answered correctly (mean Cronbach's alpha across the four samples = .704).

Job proficiency. As mentioned earlier, work sample test items were scored as a weighted percentage of task steps completed correctly. We measured job proficiency as the mean work sample test item score across all work sample items performed (mean Cronbach's alpha = .581).

Supervisor ratings. Supervisory ratings were measured as the mean task performance rating corresponding to tasks included in the work sample test battery (mean Cronbach's alpha = .887).

Motivational aspects of performance. Two indices related to "will-do" aspects of performance (previously reported by Borman et al., 1991) were available from personnel records. Disciplinary actions was coded from Unfavorable Information Files (UIF) as 0 = None, 1 = Minor infraction, 2 = Moderate infraction, or 3 = Serious infraction leading to court-martial. Awards was measured as the number of military awards and commendations received. We estimated these variables' reliabilities at .95.

Aptitude x experience cross-products. In order to test aptitude x experience interaction hypotheses, we created two cross-product terms for analyses by a) centering AFQT, TAFMS, and TaskExp scores (i.e., calculating scores' deviations about their respective means), and b) multiplying corresponding deviation scores. These deviation cross products (i.e., AFQT*TAFMS and AFQT*TaskExp) carry the appropriate interaction terms necessary to test moderator hypotheses.

Analyses

Consistent with previous research (e.g., Borman et al., 1991; Hunter, 1983; Schmidt et al., 1986), we computed meta-covariances for analysis (Jöreskog & Sörbom, 1993). Specifically, we (a) computed correlations (rs) and standard deviations (SDs) among study variables in each sample, (b) transformed rs to zs, (c) calculated sample-size weighted mean zs and SDs across samples, (d) backtransformed the mean zs to rs and (e) input the mean rs and SDs to the LISREL 8.14 program for analysis of the meta-covariance matrix. Since the models we tested were manifest variable models, we chose to correct for attenuation in model parameter estimates due to measurement error by fixing (a) the factor loading of each observed measure on its underlying construct (i.e., elements in LISREL's Λ_Y matrix) to the square root of its estimated reliability (i.e., $[\underline{r}_{YY}]^{1/2}$), and (b) the variables' residual variances (i.e., elements of LISREL's Θ_e matrix) to $(1 - \underline{r}_{YY}) * \sigma^2_{Yi}$, where σ^2_{Yi} refers to the observed measures' variances (see Bollen, 1989; Farkas & Tetrick, 1989; Williams & Hazer, 1986). We chose not to correct for range restriction on the exogenous variables because (a) incumbent populations usually are restricted on cognitive ability due to pre-employment selection on g-related selectors, (b) research participants' experience levels were within the ranges studied previously by Schmidt et al. (1988), and (c) the numbers of disciplinary actions taken and the numbers of awards given are truly restricted in the population from which our samples were obtained (first-term airmen).

Models tested. We performed two sets of analyses in parallel, with experience operationalized in terms of Job Experience and Task Experience, respectively. In each set we performed a series of nested model comparisons as recommended by Williams and Holahan (1994) and others. Beginning with the most restrictive model, we fit an uncorrelated factors model which, since each variable was operationalized using a single indicator, corresponded to a Null model (i.e., $\Sigma(\Theta) = \sigma^2_{Yi} * I$). Second, we fit a Structural Null model, in which covariances among exogenous variables (Aptitude, Experience, the AxE Interaction, Disciplinary Actions, and Awards) were free parameters to be estimated, but no causal effects were estimated between them and the endogenous variables (Job Knowledge, Job Proficiency, and Supervisory Ratings), or among the endogenous variables. Third, we fit a complete mediation model that included

Linear Effects Only from Aptitude and Experience to Job Knowledge, from Job Knowledge to Job Proficiency, and from Job Proficiency, Disciplinary Actions and Awards to Supervisory Ratings. Fourth, we fit a Complete Mediation model that included the additional effect of the AxE interaction on Job Knowledge. Fifth, we fit a Partial Mediation model that included the additional linear effects of Aptitude and Experience on Job Proficiency and Supervisory Ratings. Finally, we fit a Saturated Structural model to determine whether there existed direct AxE interaction effects on either Job Proficiency or Supervisory Ratings.

Model fit. We evaluated overall model fit in terms of (a) the overall χ^2 statistic, (b) the standardized root mean squared residual (RMSR) of the difference between the sample and reproduced covariance matrices, (c) Bentler and Bonett's (1980) normed fit index (NFI), and (d) Bentler's (1990) comparative fit index (CFI). We also evaluated differences in models' fit in terms of the difference χ^2 statistic ($\Delta\chi^2$).

RESULTS

Variables' standard deviations (SDs) and intercorrelations are shown in Table 1. In general, correlations among exogenous variables were low and nonsignificant, while correlations between endogenous variables were statistically significant and properly signed.

TABLE 1: Study Variables' Standard Deviations and Intercorrelations

Variable	SD	Intercorrelations								
		1	2	3	4	5	6	7	8	9
1. Incumbent Aptitude	17.02	1.00								
2. Task Experience	.65	.01	1.00							
3. Aptitude x Task Exp.	11.40	-.10*	.01	1.00						
4. Job Experience	10.73	.13*	.39*	-.04	1.00					
5. Aptitude x Job Exp.	183.80	.00	-.04	.41*	-.02	1.00				
6. Job Knowledge	.11	.24*	.23*	-.07	.22*	-.02	1.00			
7. Job Proficiency	1.18	.16*	.28*	-.03	.31*	-.04	.38*	1.00		
8. Disciplinary Actions	.32	-.05	-.02	.01	-.04	.02	-.05	-.08	1.00	
9. Number of Decorations	.25	-.02	.04	-.03	.26*	-.08	.09	.08	-.06	1.00
10. Supervisor Ratings	.66	.05	.24*	.03	.22*	-.05	.21*	.27*	-.11*	.15*

* $p < .01$

Table 2 shows overall goodness of fit statistics for the Job and Task Experience models tested. All indications were that the Partial Mediation model provided the best fit to the data: the χ^2 statistics were nonsignificant for both the Job and Task Experience models, RMSRs were below .03, and NFIs and CFIs were larger than .95 in both cases. More specific model comparisons indicated that exogenous variables were significantly interrelated for the Job Experience model (Null vs. Structural Null models $\Delta\chi^2(8) = 71.60$, $p < .001$), but not for the Task Experience model ($\Delta\chi^2(8) = 6.77$, $p > .05$). Both models supported hypotheses of mediated linear relationships of the form hypothesized by Borman et al. (1991) (Structural Null vs. Linear Effects Only models $\Delta\chi^2(6) = 276.72$, $p < .001$ and 289.57 ; $p < .001$, for the Job and Task Experience models, respectively), but neither supported Aptitude x Experience interactive effects on Job Knowledge (Linear Effects Only vs. Complete Mediation models $\Delta\chi^2(1) = .47$, $p > .05$, and 1.73 ; $p > .05$, for the Job and Task Experience models, respectively). Both models also supported the ideas that Job Knowledge only partially (and not completely) mediates effects of Aptitude and Experience on other endogenous variables (Complete Mediation vs. Partial Mediation models $\Delta\chi^2(5) = 35.84$, $p < .001$, and 35.95 ; $p < .001$, for the Job and Task Experience models, respectively), and that there were no Aptitude x Experience interaction effects on either Job Proficiency or Supervisor ratings (Partial Mediation vs. Saturated Structural models $\Delta\chi^2(2) = 1.15$, $p > .05$, and 1.81 ; $p > .05$, for the Job and Task Experience models, respectively). Nevertheless, somewhat different patterns of results were obtained for the Job versus Task Experience models.

TABLE 2: Overall Model Goodness-of-Fit Indices

	df	Job Experience Model				Task Experience Model			
		χ^2	RMSR	NFI	CFI	χ^2	RMSR	NFI	CFI
Saturated Structural	6	4.82	.014	.99	1.00	17.20	.028	.95	.97
Partial Mediation	8	5.97	.016	.98	1.00	19.01	.029	.95	.97
Complete Mediation	13	41.81*	.036	.89	.92	54.96*	.045	.84	.87
Linear Effects Only	14	42.28*	.038	.89	.92	56.69*	.046	.84	.87
Structural Null	20	319.00*	.130	.18	.18	346.26*	.130	.02	.00
Null	28	390.60*	--	--	--	353.03*	--	--	--

Note. RMSR = Standardized root mean squared residual, NFI = normed fit index, CFI = comparative fit index.

* $p < .001$.

Figures 2 and 3 show standardized structural parameters (path coefficients) for the Job and Task Experience models, respectively. Results shown for the Job Experience model are largely consistent with previous research. As in Schmidt et al. (1986) and Borman et al. (1991), results support the idea that Job Knowledge mediates exogenous variables' effects on Job Proficiency and Supervisor Ratings. Also, as in Borman et al. (1991), Supervisor Ratings reflect

the influence of both “can-do” aspects of performance (i.e., Job Proficiency) and “will-do” aspects (i.e., Disciplinary Actions and Awards). Also consistent with Schmidt et al. (1986) Job Experience had a direct effect on Job Proficiency as well as an indirect effect through Job Knowledge. Thus, results indicate that the primary benefit of Cognitive Ability is in terms of facilitating learning the job, whereas Job Experience benefits both job learning and actual proficiency in performing job duties.

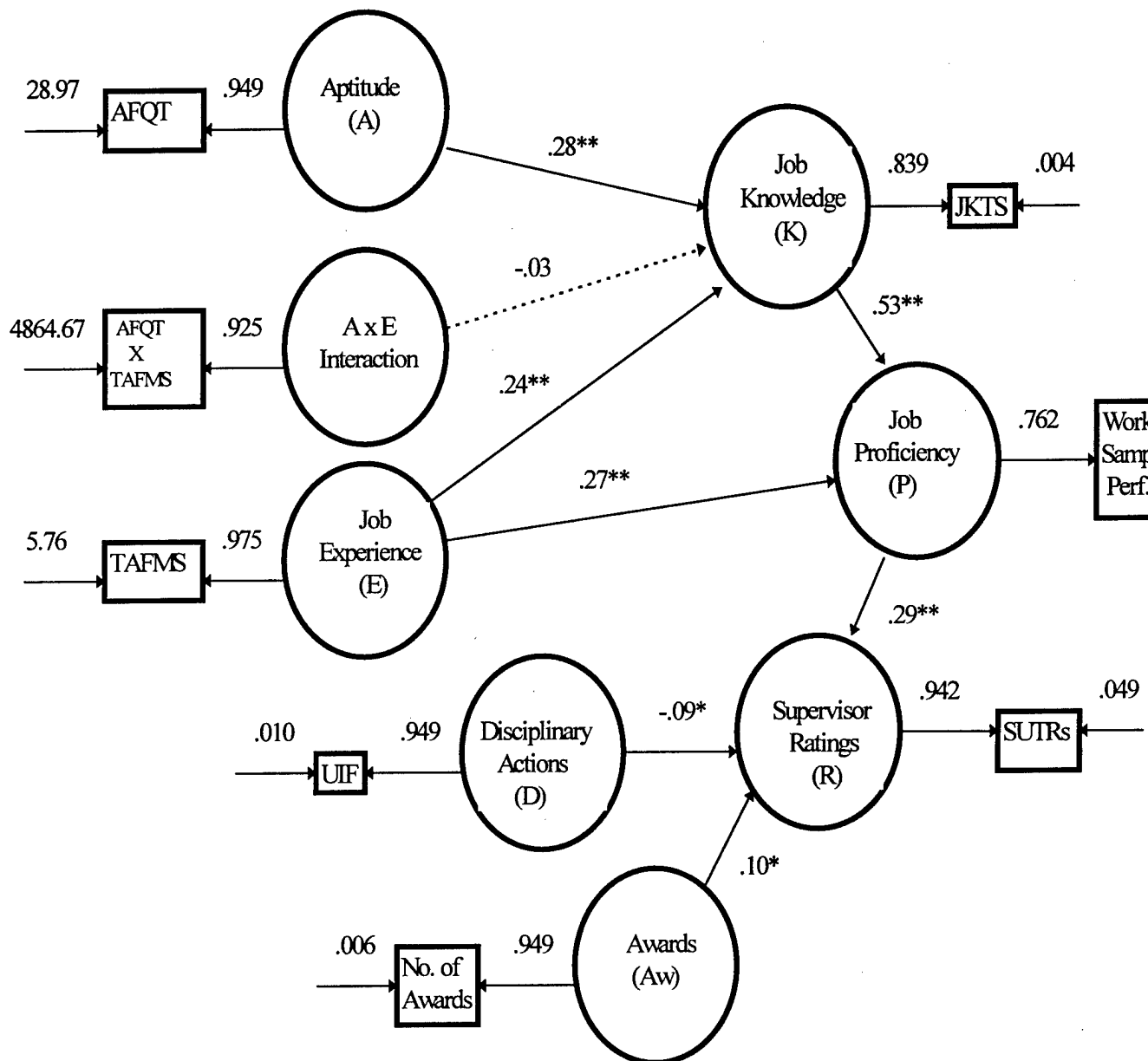


Figure 2. Results for Job Experience Model.

Results for the Task Experience model (shown in Figure 3) are similar for the Job Experience model, but here Task Experience plays a larger role: in addition to enhancing Job Knowledge and Job Proficiency, Task Experience also had a direct effect on Supervisory Ratings. Thus Task Experience, as it is tied more closely to the tasks actually performed on the job (vs. simply the length of time spent on the job), appears to facilitate learning the job (i.e., enhances Job Knowledge), enhance Job Proficiency directly (from increased opportunities to perform job tasks), and affect Supervisor Ratings.

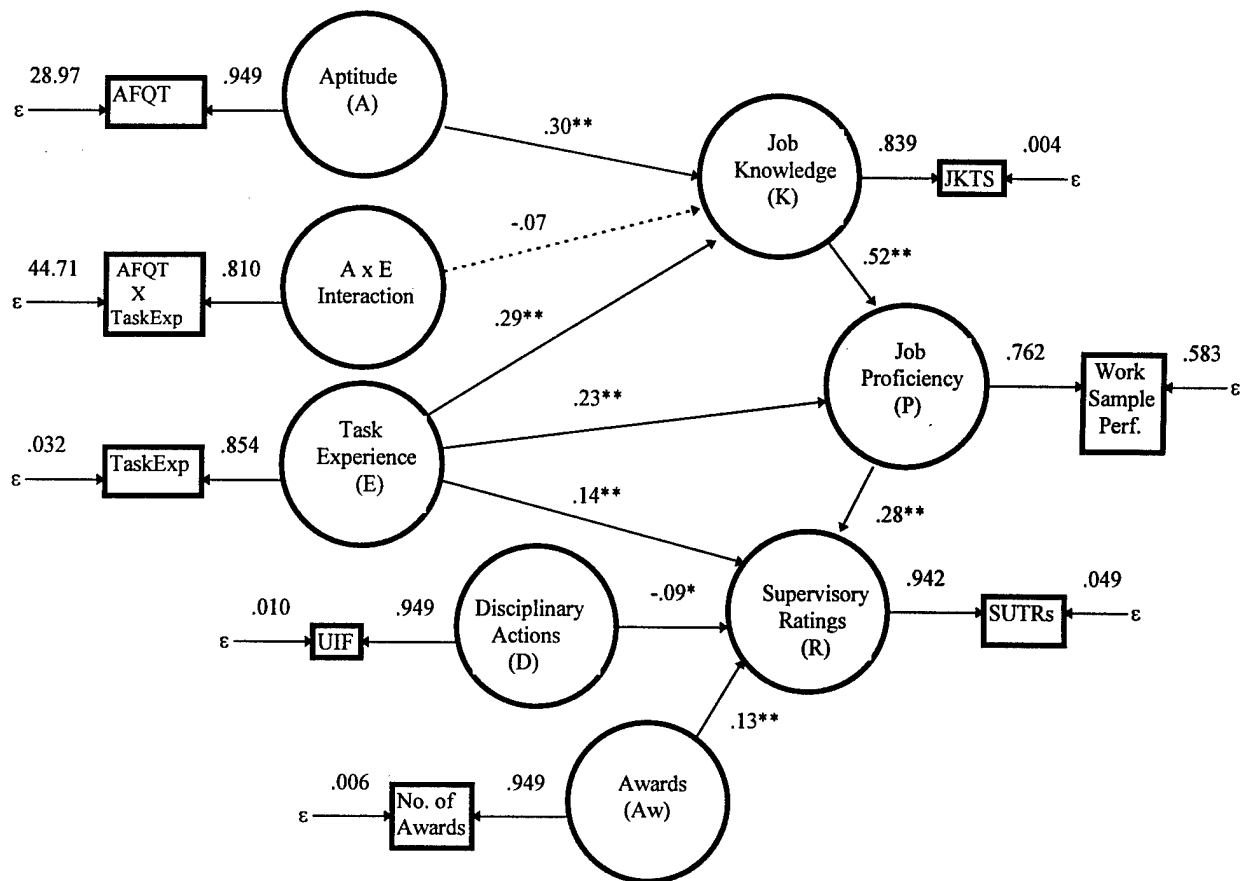


Figure 3. Results for Task Experience Model.

DISCUSSION

Although there is some evidence of ability x experience interactive effects on performance (Lance et al., 1989), the present findings supported other empirical literature which indicates only linear and additive effects (e.g., McDaniel et al., 1988). Failure to detect significant ability x experience interactions may reflect general difficulties in the detection of moderated relationships in nonexperimental data (McClelland & Judd, 1993), or that these effects are, in fact, linear in the population. Failure to detect ability x experience interaction effects might also be due to direct range restriction on (a) ability due to the selection of participants, in part, on AFQT scores, and (b) experience, since all participants were in their first term of enlistment.

Results showed that Job and Task Experience were only modestly intercorrelated ($r = .39$), supporting the idea that they reflect different underlying experience constructs. Both exerted direct effects on Job Knowledge and Job Proficiency. We see these beneficial effects of Experience as arising from increased declarative knowledge (effects on Job Knowledge) and procedural knowledge and skill (effects on Job Proficiency). However, only Task Experience had a direct effect on Supervisory Ratings. This may reflect a tendency for supervisors to bias ratings in favor of incumbents who perform certain tasks more often, or the possibility that higher performers are more readily called upon to perform job tasks than are poorer performers (Ford, Quiñones, Sego, & Sorra, 1992).

As discussed in the previous paragraph, effects of Experience were only partially mediated by job knowledge and job proficiency. However, a complete mediational model was supported for the Aptitude \rightarrow Job Knowledge \rightarrow Job Proficiency \rightarrow Supervisory Rating relationships. This suggests that (a) the primary benefit of aptitude is increased job knowledge, (b) job knowledge facilitates the acquisition of procedural knowledge and skills (manifested in Job Proficiency), and (c) Supervisor Ratings reflect how well incumbents do their jobs (Job Proficiency) and not what they know about it (Job Knowledge).

Finally, we found that both "can-do" and "will-do" aspects of performance affected Supervisory Ratings. This points to the importance of considering "extra-role" behaviors or "contextual performance" (Borman & Motowidlo, 1993; Motowidlo & VanScotter, 1994) as well as "in-role" behaviors in models of job performance and performance rating.

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